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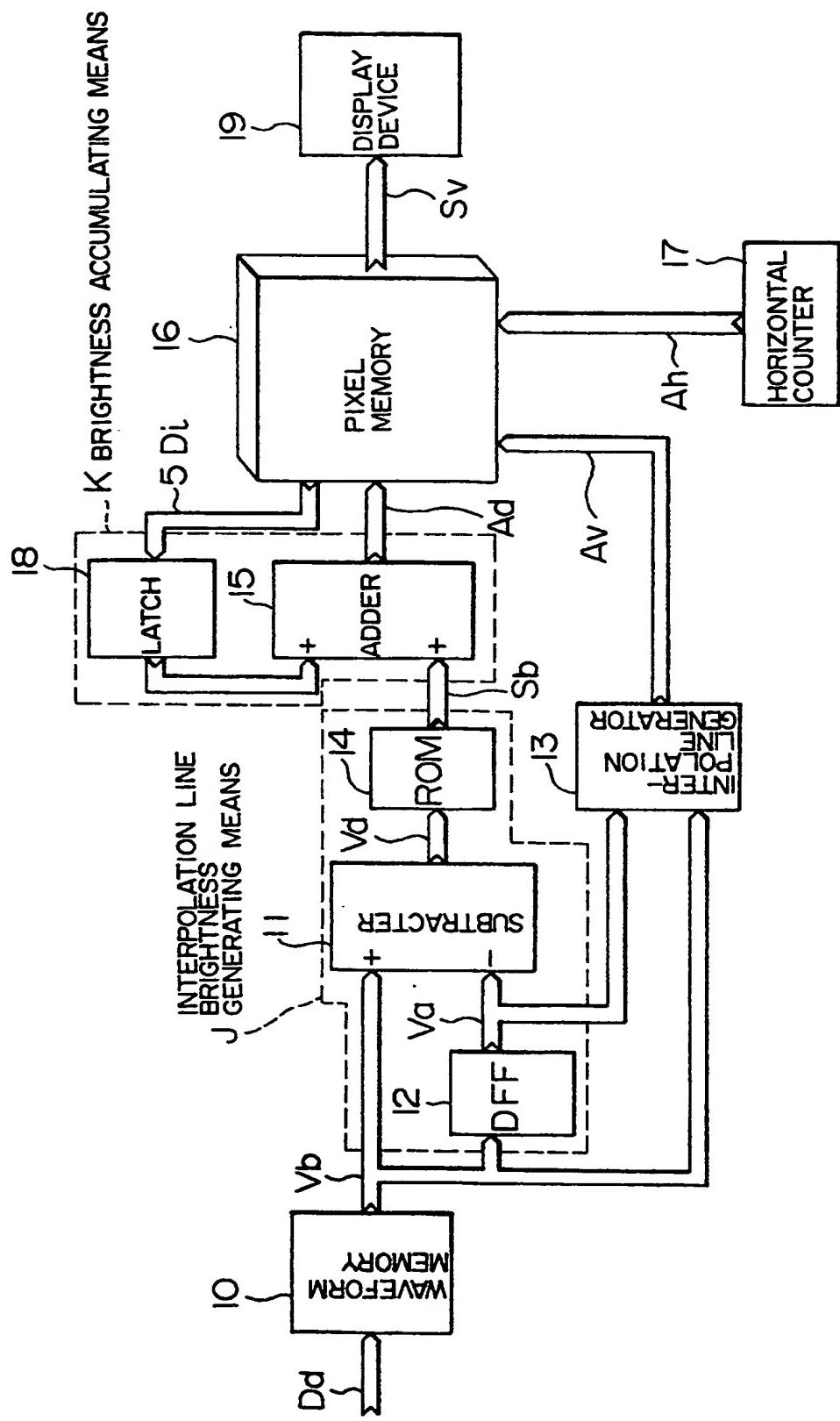
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(54) **Waveform displaying device.**

(57) A waveform displaying device, in which a measured analogue signal is converted into a digital signal by means of an analogue to digital converter and thereafter the digital signal is directly inputted in a display device (19) such as a raster scanning display, a liquid crystal display device, effecting the display while controlling the brightness of pixels so as to reproduce to display waveform of the measured analogue signal. In the present device the brightness of pixels is varied, depending on slew rate of the waveform, so that the brightness of interpolation lines is increased, when differences between inputted waveform data are small, and the brightness is decreased, when the differences are small. Further places, where the density of waveforms is high, are displayed brightly by accumulating the brightness thereof. In this way, since peculiar points in the waveforms such as points, at which the phase, the frequency or the amplitude is varied, are displayed as points, at which the brightness is varied, it is possible to find easily these points and further observation is easy, also in the case where a number of waveforms are displayed, superposed on each other.

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## BACKGROUND OF THE INVENTION

### Field of the Invention

The present invention relates to a waveform displaying device, which can be utilized for a digital oscilloscope, etc. reproducing to display waveform of a measured analogue signal on the basis of waveform data, into which the measured analogue signal is digital-converted.

### Description of the Related Art

A waveform observing device such as a digital oscilloscope, etc. is provided with an analogue to digital converter, a waveform memory and a waveform displaying device. It stores waveform data obtained by converting an observed analogue signal into a digital signal with a predetermined period by means of the analogue to digital converter in the waveform memory and reads out the waveform data stated above at need from the waveform memory to transfer them to the waveform displaying device in order to reproduce to display the waveform of the measured analogue signal described above. Heretofore the waveform displaying device converts digital waveform data into an analogue signal by means of a digital to analogue converter and effects the reproduction and the display of the waveform by using this analogue signal as a deflection signal for a CRT. However, if a number of different waveforms are displayed by such a waveform displaying device, the scanning distance with a beam in the CRT becomes long and the display brightness is reduced. Further, since it is necessary to sweep the beam with a high speed in order to prevent fluctuations in the display, the CRT is restricted to be of electrostatic deflection type. The depth of an electrostatic deflection type CRT is great with respect to the display area and it cannot be desired to reduce the size of the device.

On the other hand, recently a waveform displaying device provided with a pixel memory and a display device, in which the display is effected by controlling brightness of pixels; e.g. a raster scanning display or a liquid crystal display, is used in practice. The waveform displaying device stated above is so constructed that interpolation processing is executed between different waveform data by a CPU; the waveform is traced in the pixel memory; and the waveform is reproduced to be displayed by transmitting successively brightness information stored in this pixel memory to the display device.

When the waveform displaying device described above is used, in the case where a number of different waveforms are displayed, since these waveforms are synthesized in the pixel memory, the brightness of the display is not reduced. Further, the depth of the raster scanning display or the liquid crystal display is smaller

than that of the electrostatic deflection type CRT, which makes it possible to reduce the size of the device.

However, since the display resolving power of the

- 5 raster scanning display or the liquid crystal display is not so high, in the case where the number of waveform data is greater than the number of display pixels, a method, by which the maximum value and the minimum value are detected for every predetermined period of time and only interpolation lines connecting these data are displayed are used. By such a method, since many waveform data have been already thinned out, much information is lost. When it is displayed, a uniform band is formed and therefore it is impossible to find variations in the slew rate and the phase.

### SUMMARY OF THE INVENTION

- 20 The present invention has been done in order to solve the problems of the conventional technique described above and the object thereof is to provide an excellent waveform displaying device capable of displaying waveform data of large quantity, without losing any information which they have.

In order to achieve the above object, a waveform displaying device according to the present invention, which reproduces to display a waveform of a measured analogue signal on the basis of waveform data, into which the measured analogue signal is digital-converted by means of an analogue to digital converter, is characterized in that it comprises displaying means for effecting the display while controlling the brightness of pixels; a pixel memory for outputting the brightness of pixels to the displaying means stated above; interpolation line brightness generating means for obtaining the brightness of each of interpolation lines by using differences between inputted waveform data; and brightness accumulating means for accumulating the brightness of the interpolation lines from the interpolation line brightness generating means stated above in the corresponding pixels in the pixel memory.

In this way, according to the present invention, the brightness is varied, depending on the slew rate of waveform, if the brightness of the relevant interpolation line is increased, e.g. when differences between waveform data are small, and on the contrary the brightness of the relevant interpolation line is decreased, when the differences are great. Further, places where the density of waveform is high are displayed brightly by the accumulation of the brightness. That is, since variations in the waveform are displayed together with information on the brightness, it is possible to display waveform data of large quantity even by using a display device having a low resolving power.

## BRIEF DESCRIPTION OF THE DRAWING

Fig. 1 is a schematical block diagram showing a waveform displaying device in an embodiment of the present invention.

## DESCRIPTION OF THE PREFERRED EMBODIMENTS

Hereinbelow the present invention will be explained, referring to the drawing.

Fig. 1 is a block diagram indicating an embodiment of the waveform displaying device according to the present invention.

In Fig. 1, a waveform memory 10 takes waveform data Dd from an analogue to digital converter to store them. The waveform data stored in the waveform memory 10 are inputted in a subtracter 11, a D flipflop (hereinbelow called "DFF") 12 and an interpolation line generator 13. The DFF 12 outputs waveform data Va preceding directly waveform data Vb. These waveform data Va are inputted in the subtracter 11 and the interpolation line generator 13. In this way the subtracter 11 calculates the difference Vd between the waveform data Va and the waveform data Vb inputted therein to output it. This difference output Vd of the subtracter 11 is inputted in an address of a brightness calculating ROM 14. The ROM 14 outputs brightness data Sb of an interpolation line, responding to the difference Vd. The brightness data Sb described above is inputted in an adder 15. Here the subtracter 11, the DFF 12 and the ROM 14 constitute interpolation line brightness generating means J.

The interpolation line 13 generates successively vertical addresses for all the pixels corresponding to the interpolation line of the inputted waveform data from Va to Vb. The addresses generated by the interpolation line generator 13 are inputted in vertical address Av of the pixel memory 16. A horizontal counter 17 specifies the horizontal position of the interpolation line and the output of this horizontal counter 17 is inputted in horizontal address Ah of the pixel memory 16. The pixel memory 16 outputs brightness data Di of the pixels specified by the vertical address Av and the horizontal address Ah. These brightness data Di are inputted in a latch 18 and held therein. The output of the latch 18 is inputted in an adder 15 to be added there to brightness data Sb of the interpolation line. This adder 15 and the latch 18 constitute brightness accumulating means K.

The output of the adder 15 is written in the pixel memory 16 as the brightness data for the pixels specified by the vertical address Av and the horizontal address Ah described above. The display device 19 reads out successively the brightness data Sv from the pixel memory 16 to display them.

The waveform displaying device constructed as described above will be explained, referring to Fig. 1.

The waveform data converted into a digital signal by means of an analogue to digital converter, with a predetermined period are stored in the waveform memory 10. When waveform data for one frame are written in the waveform memory 10, it outputs successively the waveform data Vb for the display. The waveform data Vb are inputted in the subtracter 11, the DFF 12 and the interpolation line generator 13. The DFF 12 outputs the waveform data Va preceding directly the waveform data Vb outputted by the waveform memory 10. In this way, the subtracter 11 calculates the difference Vd = Vb - Va between the two waveform data sets.

The brightness of the interpolation line is calculated by inputting the difference Vd of the waveform data in the ROM 14. The brightness I calculated by using e.g. a following formula:

$$I = k |Vd| + 1 \quad (1)$$

is written in the ROM 14 in the form of a table.

In this Eq. (1)  $|Vd|$  represents the absolute value of the difference of the waveform data and k is a constant.

By the method as described in the above example the part, where the slew rate of the waveform is high, is displayed darkly and the part, where the slew rate is low, is displayed brightly. The brightness data Sb are inputted in the adder 15.

In the case where the waveform is reproduced to be traced in the pixel memory 16, it is necessary to interpolate the waveform data by using a line. In the case where the number of waveform data sets in one frame is greater than the number of display pixels in the horizontal direction, the interpolation line is a straight line in the vertical direction. Consequently, in order to trace an interpolation line from the waveform data Vb to Va, the brightness of the interpolation line may be written in all the pixels in the vertical direction from Vb to Va.

In order to realize it, the interpolation line generator 13 generates successively vertical address Av from the inputted waveform data Vb to Va. The vertical address Av described above and the horizontal address Ah generated by the horizontal counter 17 are inputted in the pixel memory 16. In this way all the pixels of the interpolation line are accessed one after another and the brightness of each of the pixels is increased by the respective brightness of the interpolation line by the latch 18 and the adder 15. In the case where the number of waveform data sets in one frame is n times as great as the number of display pixels in the horizontal direction, n interpolation lines in the vertical direction are written in a same horizontal address, superposed on each other. In order that no brightness information is lost by the superposed writing, the brightness is accumulated by the latch 18 and the adder 15. When one interpolation line has been once traced, the output of the DFF 12 is updated and the waveform memory 10 outputs following waveform

data.

Thereafter succeeding interpolation lines are traced in the same manner as described above. In the case where the number of waveform data sets in one frame is  $n$  times as great as the number of display pixels in the horizontal direction, as described previously, every time  $n$  interpolation lines are traced, the horizontal address  $A_h$  in the horizontal counter 17 is increased by 1. When the trace of one frame is terminated, the brightness information is transferred to the display device 19 to be displayed there.

In the case where a number of waveforms are displayed, if the waveforms are accumulated in the pixel memory on each other, parts where waveforms are superposed are displayed brightly.

As clearly seen from the embodiment described above, according to the present invention, since the brightness of the interpolation line is varied, depending on the slew rate and the brightness is accumulated by superposing interpolation lines, even in the case where a dense waveform having a high frequency is displayed, points, at which the phase, the frequency or the amplitude is varied, are displayed as points, at which the brightness is varied, and therefore an effect can be obtained that it is possible to find easily peculiar points in the waveform. further, according to the present invention, it is possible to display a number of waveforms and another effect can be obtained that observation is easier, because superposed parts become clearer.

said interpolation line brightness generating means is inputted in said brightness accumulating means so that variations in slew rate are also displayed by brightness modulation.

- 5                    3. A waveform displaying device, which reproduces to display a waveform of a measured analogue signal on the basis of waveform data, into which the measured analogue signal is digital-converted by means of an analogue to digital converter, comprising:
- 10                  displaying means (19) for effecting the display while controlling the brightness of pixels;
- 15                  a pixel memory (16) for outputting the brightness of pixels to said displaying means;
- 20                  interpolation line brightness generating means (J) for obtaining the brightness of each of interpolation lines by using differences between inputted waveform data; and
- 25                  brightness accumulating means (K) for accumulating the brightness of the interpolation lines from said interpolation line brightness generating means in the corresponding pixels in said pixel memory.

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### Claims

1. A waveform displaying device, which reproduces to display a waveform of a measured analogue signal on the basis of waveform data, into which the measured analogue signal is digital-converted by means of an analogue to digital converter, comprising:
- 35                  displaying means (19) for effecting the display while controlling the brightness of pixels;
- 40                  a pixel memory (16) for outputting the brightness of pixels to said displaying means;
- 45                  brightness accumulating means (K) for writing a plurality of interpolation lines in said pixel memory, accumulating the brightness thereof by superposing them on each other;
- 50                  wherein a compressed waveform is displayed by brightness modulation.
- 55                  2. A waveform displaying device according to Claim 1, further comprising interpolation line brightness generating means (J) for determining the brightness of the interpolation lines by using differences between waveform data, wherein the brightness for every interpolation line obtained by

FIG. I

